

Air Pollution Impacts and Reduction Strategies

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Table of Contents

Abstract	3
Introduction	4
Materials and Methods	5
Results	6
Discussion and Conclusion	8
Acknowledgements	10
References	12
Tables	13
Figures	14

Abstract

Air Pollution Impacts and Prevention. STACI GARCIA (Southwestern Oklahoma State University, Weatherford, OK 73096) R. Stanley (National Renewable Energy Laboratory, Golden, CO 80401).

The quality of our air is of utmost concern. Increasing uses of fossil fuels has caused increased levels of air pollutant emissions. The notion that consumers share responsibility for this pollution has been widely accepted. Fossil fuel emissions are responsible for adverse health effects common in children, the elderly and athletes. Studies were collected that have detailed the relationship between harmful air pollutants and negative health effects. The results of the studies, presented in this paper, have provided conclusive evidence of the link between air pollution and adverse health. Energy efficiency strategies and renewable energy technologies provide possible solutions to lowering pollutant emissions. Studies presented here show that wind and solar technologies are cost competitive with traditional energy sources and will have a positive impact on the future of humans and the environment. These renewable energy sources are continually replenished and are free to consumers after an initial investment. Further work is required to implement more stringent emission standards. Added research in renewable technologies is also warranted. These efforts will benefit the well-being of humans, the environment and our natural resources.

Category (circle one): Physical – Life – Engineering

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Introduction

There is a growing concern that the air we breathe may contain pollutants that put us at risk for future health problems. The most significant sources of air pollution are vehicle emissions, industry and power plants (Friedman, et al. 2001). Research confirms that air pollution contributes to illness and mortality (Kunzli, et al. 2000) and that these pollutants are most harmful to children, athletes and the elderly.

Air pollution is impacting the lives of millions of people by causing damage to humans and the environment that may prove to be irreversible. Conditions that are exacerbated by air pollution include asthma, cardiovascular disease, pneumonia and others (Kunzli, et al. 2000).

Much of the air pollution affecting humans and the environment is the result of human activity. These activities have increased due to population growth, increased energy consumption and augmented industrial production. Evidence exists which indicates that humans will be negatively impacted if environmental degradation continues (Dincer 1999). From a health perspective, there are moral obligations to communicate this impact to the public (Kunzli, et al. 2000).

There are several potential solutions for reducing air pollution and its harmful effects. One approach to reducing emissions is to focus on increasing energy efficiency. Energy efficiency equates to money saved while securing the energy supply (Dincer 1999).

Research suggests that renewable energy technology could be another of these solutions. Renewable energy technologies have been developed, in part, to combat the results of fossil fuel depletion. Though there are many existing and emerging renewable technologies, this paper focuses on wind and solar. Significant research effort has been made to improve efficiency while

lowering manufacturing costs. These renewable energy technologies can have a beneficial impact on the future by reducing air pollution that is attributable to the burning of fossil fuels.

The purpose of this research paper is to provide a collection of study results that link adverse health effects to air pollution, and to provide strategies for reducing these air pollutants in the earth's atmosphere. Information regarding the reduction of air pollution by use of wind and solar renewable energy technologies is discussed. This research shows that reducing toxic air pollutants in the atmosphere, by implementing energy efficiency programs and using renewable energy sources, benefits public health and the environment. These benefits are best measured when compared with the damage costs associated with emissions.

Materials and Methods

Factors such as population growth, economic performance and technological developments will shape the future of energy consumption. Studies have been conducted to project the world's energy demand for the next 20 years. This information was used to determine probable energy sources and suggest possible alternatives (Dincer 1999).

Various scientists have performed studies to link air pollution to adverse health effects. Harvard University tracked the health of more than 8,000 people living in six heavily polluted areas. A nationwide study known as the National Morbidity, Mortality and Air Pollution Study (NMMAPS) was commissioned to predict the short-term effects of air pollution. This was accomplished by conducting field studies using statistical techniques to track patients and medical records. Work has also been performed by the University of Southern California to track the respiratory health of school children in a dozen southern California communities (ALA

2001). The information gathered from these sources was used to assess the negative impacts of air pollutants on human health.

Results

Scientists have predicted that continued environmental degradation has a negative effect on humans. The idea that consumers share responsibility for pollution resulting from fossil fuel use is well known (Dincer 1999). The main sources of air pollutants are vehicle exhaust, industry and power generation plants (Table 1). Experimental, laboratory and epidemiological studies have linked high concentrations of known air pollutants to respiratory health problems (Friedman, et al. 2001).

Pollutants emitted at a high rate by diesel engines have been targeted as being most responsible for health damages. These emissions are most harmful to health because they contain many toxic chemicals and contribute to the formation of the smallest aerosol particles. The smallest particles are most damaging to human health because they have the largest surface area per unit weight and penetrate deep into the lungs (Schimek 2001).

A study performed in Ostrava, Czech Republic, found that industrial production leads to the severe damage of human health and the environment. In Ostrava environmental pollution, particularly air pollution produced by heavy industry, is a growing problem. The community has experienced elevated mortality caused by the increased incidence of cancer and cardiovascular disease (Slachtova, et al. 1998).

In 1993, Harvard University conducted the Six Cities Study by following the health of 8,000 people living in areas along a gradient of air pollution concentrations for 14-16 years. With increased concentrations of air pollutants, there was a similarly proportional increase in the

death rate of those studied. The study reported that automobile sources, as well as coal combustion sources, accounted for increases in daily mortality. Those residents in the most polluted city had a 26 percent increased risk of premature death compared to the cleanest city in the study (ALA 2001).

The Health Effects Institute, with investigators from Johns Hopkins School of Public Health and Harvard University, commissioned a nationwide study of the short-term effects of air pollution on human health, also known as the National Morbidity, Mortality and Air Pollution Study. The 90 largest U.S. cities were studied, and strong evidence was found linking daily increases of particle pollution to increases in death (ALA 2001). In a similar study by the same group, 14 U.S. cities were found to exhibit strong and consistent associations between particulate air pollution and hospital admissions among the elderly (ALA 2001).

Air pollutants were monitored in a dozen southern California communities, while tracking the respiratory health of more than 3,000 school children in the area. Researchers from the University of Southern California found significant deficits in growth of lung function associated with fine particle pollutants. Deficits were most significant in those children that spent more time outdoors (ALA 2001).

Research by Abt Associates, Inc., a for-profit government and business consulting firm, estimates that 30,100 deaths, 20,100 hospitalizations, and 7,000 asthma-related emergency room visits can be attributed to power plant emissions each year in the U.S. (Fig. 1). In addition, the analysis showed that more than 5 million lost work days and more than 26 million restricted activity days were due to emissions by power plants. The focus of the study was on emissions of SO₂ and NO_x (ALA 2001).

Several potential solutions to the current environmental and health problems associated with harmful emissions have evolved. Many energy efficiency programs for homeowners have been developed to reduce the present level of energy consumption. The implementation of energy efficiency programs result in lower energy demand, thus reducing the impact on the earth and human health. Consumer energy costs can also be reduced by adopting appropriate efficiency measures. Many energy efficiency programs have a payback period of less than two years (Dincer 1999). In addition, appliance manufacturers and builders are striving to produce more energy efficient products. Ideally these products will result in reduced energy consumption, which generally leads to lowered emission levels.

Scientists have suggested that renewable energy technologies be selected over fossil fuel or nuclear projects because of their external benefits. These benefits exist in the form of lower emissions, fewer health related incidences and conserved resources. Many renewable energy technologies are now cost competitive with fossil fuel technologies, though investment in a renewable technology requires long-term planning. Costs must be calculated over the operational lifetime of the project (Dincer 1999). Research has shown that energy efficiency and renewable energy systems can have a beneficial impact on society.

Discussion and Conclusion

Studies during the last 20 years have provided conclusive evidence of a link between air pollution and harmful health effects. The negative health impacts include respiratory symptoms, chronic bronchitis, asthma exacerbation and increased death rates. Pollution reduction will have multi-dimensional benefits to both humans and the environment (El-Fadel and Massoud 2000). Energy efficiency and renewable energy implementation will likely play a large role in emission

reduction. Coal, oil, and natural gas consumption will inevitably decrease as the available supply diminishes (Fig. 2). Renewable energies such as wind and solar, though intermittent, are sustainable as they are continually replenished. Investment in these renewable energy technologies offers the advantage of free “fuel” for producing energy.

Environmental and economic issues offer that priority be given to more efficient uses of energy. Energy efficiency plays a key role in pollution reduction (Dincer 1999). Energy efficiency requires improvements such as replacement of less efficient appliances, HVAC improvements, and the use of energy efficient lighting, among others.

The United States has obtained economic benefits by investing in energy efficiency research and development. Seventeen energy efficiency projects, representing a \$1.6 billion investment, are estimated to yield net benefits of \$30 billion. The three Department of Energy projects that have resulted in the most economic benefit included refrigerator and freezer compressors, energy efficient fluorescent lighting and low emission window glass (EREN 2001a).

Another example of energy efficiency is illustrated by measures taken in Berkeley, California. The city of Berkeley replaced every incandescent light bulb on one city block with energy efficient compact fluorescent bulbs. This switch cut electricity use on that block by 45 percent and saved an estimated 62,712 kWh per year (EREN 2001b).

Significant reductions in energy costs can occur when appropriate efficiency measures are taken. Many energy efficiency programs have a payback of less than two years. Reduced energy consumption benefits consumers, resulting in less energy used, dollars saved and reduced pollutant emissions. Energy efficiency programs will ultimately benefit consumers, utilities, and society as a whole (Dincer 1999).

Solar power can be used in many ways including passive solar heating, daylighting and solar electricity. When being used as a heat and light source, solar energy is almost entirely free. The basic features of passive systems are south-facing windows to transmit sunlight into the space for daylighting and dark tile with added mass or brick to absorb heat for warming the area. Solar electricity requires the use of photovoltaic (PV) technology to turn solar energy into electricity. PV systems tend to be more expensive than other renewable technologies. However, PV systems are quiet, non-polluting, reliable, and can be used anywhere on Earth. In remote areas, the use of PV systems eliminates the need for costly electric transmission line installations. In these applications, it is the lowest cost alternative. For instance, remote water pumping for livestock can be prohibitively expensive and impractical when using a diesel generator. A solar powered water pump can be relatively inexpensive, reliable and portable. The cost of using PV technology is steadily falling (Fig. 3) and the efficiency of these systems continues to rise (NREL 1996). Integrated PV installations currently cost approximately \$10/W. And, stand alone installations have a current range of \$6-\$8/W compared to \$25-\$30/W in the early 1980s.

Electricity generated from wind energy is the fastest growing source of energy in the world. Wind energy is converted to power through wind turbines. The efficiency and reliability of wind turbines has risen within the past 15 years, allowing industry to lower the cost of wind generated electricity. A dramatic reduction in wind energy costs has been the result of continuing technology improvements. The cost of generating electricity from wind energy in 1980 was approximately \$0.35 kWh, and it can now be generated for as little as \$0.05 kWh in areas with good wind sources (Fig. 4). The improvements in and cost reduction of these turbines contributes to making wind energy one of the cheapest renewable technologies (NREL 1999). These turbines can, in some instances, pay back the energy used to manufacture them

within four months of operation (ATSE 2001). Like solar, wind energy is non-polluting and “environmentally friendly.”

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Tables

National Emission Trends

Emission Sources	Pollutant Produced (%)			
	<i>CO</i>	<i>NO_x</i>	<i>SO₂</i>	<i>VOC</i>
<i>Transportation</i>	78.6	53.3	7.1	43.5
<i>Fuel Combustion</i>	6.0	41.7	85.1	5.0
<i>Industrial Processes</i>	5.4	3.7	7.7	47.2
<i>Other</i>	10.0	1.3	.1	4.3
Total	100.0	100.0	100.0	100.0

Table 1 Source: 1998 EPA National Air Quality and Emissions Trends Report

Figures

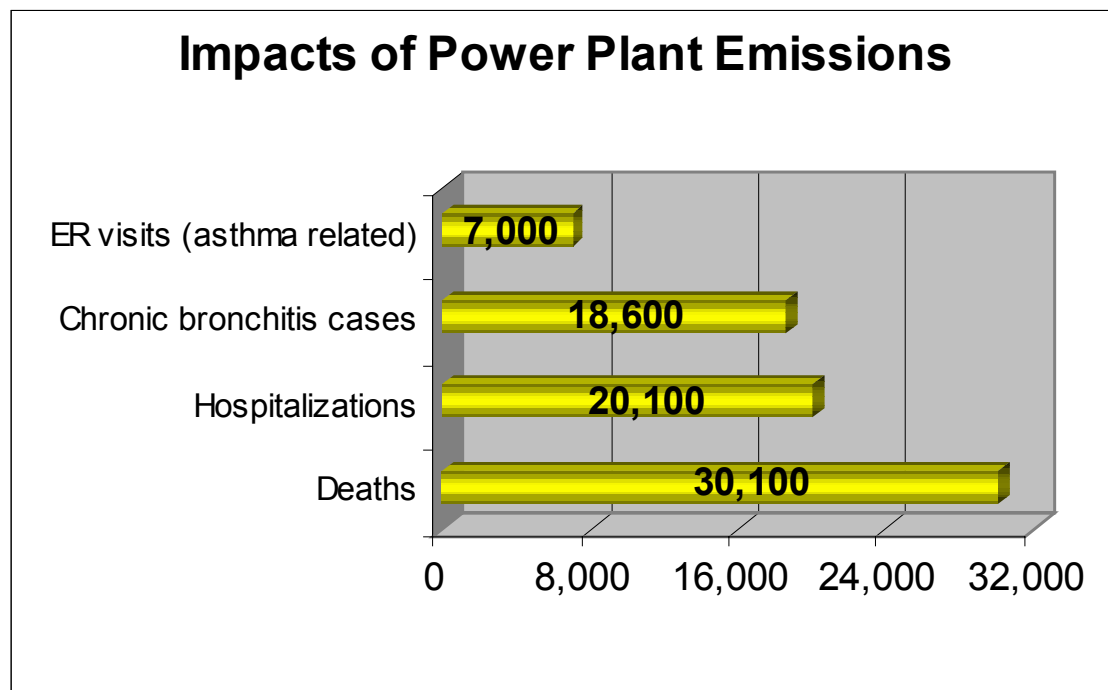


Fig. 1 Source: 2001 American Lung Association Selected Key Studies on Particulate Matter and Health

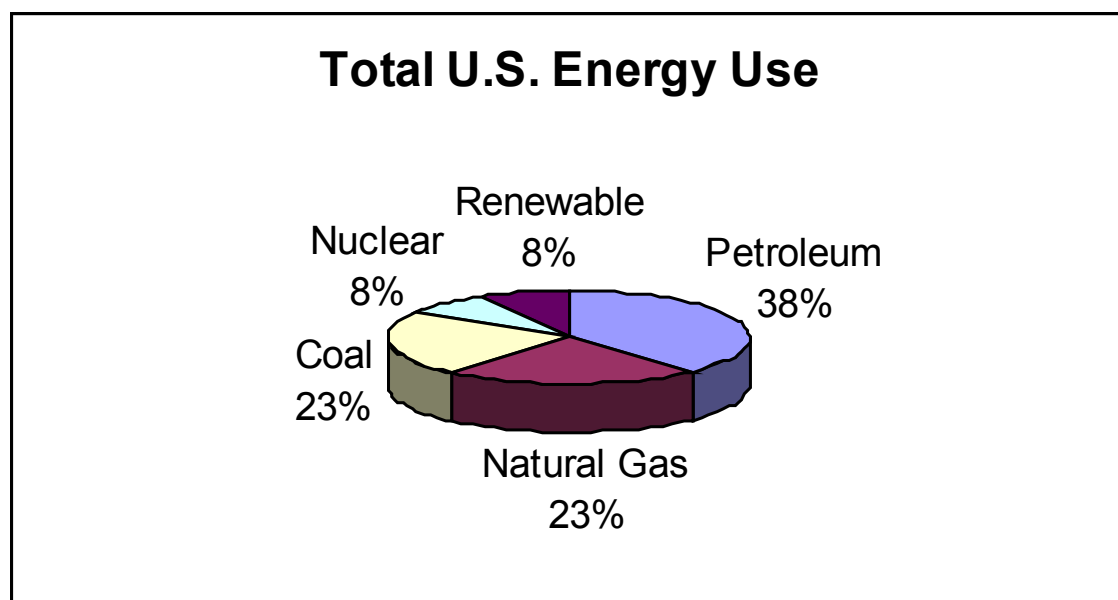


Fig. 2 Source: 2001 Solarbuzz, Inc. US National Energy Mix for 1998

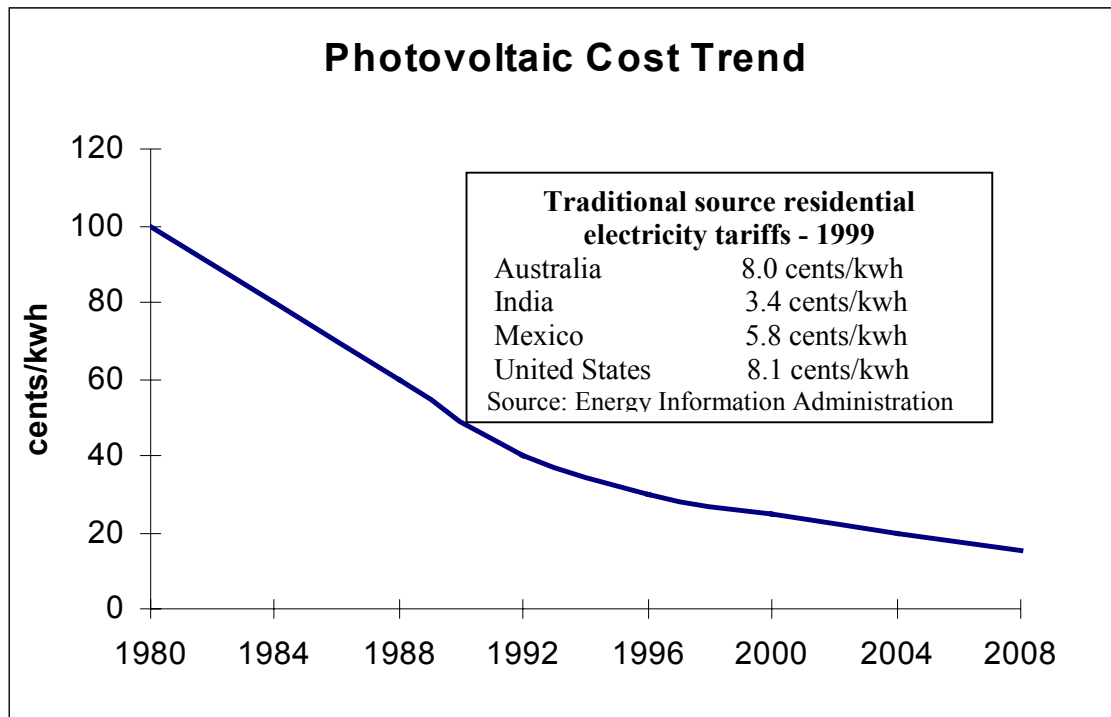


Fig.3 Source: NREL technology manager, November 1997

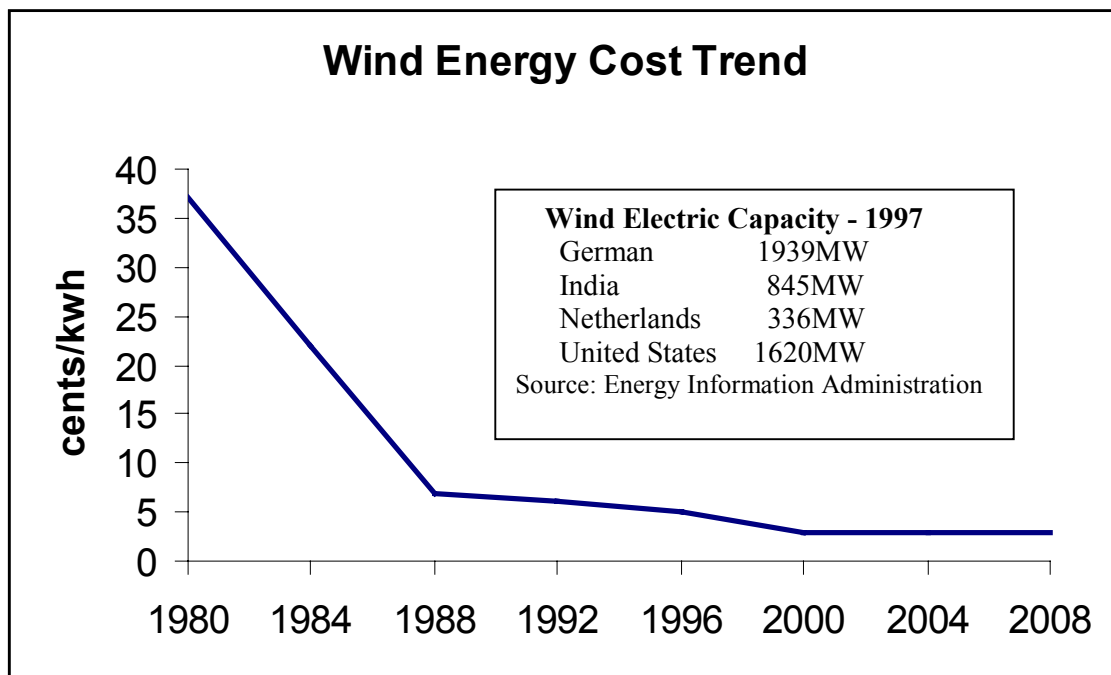


Fig. 4 Source: NREL technology manager, November 1997